行政院國家科學委員會專題研究計畫 成果報告

再探異質寡占市場中數量競爭與價格競爭之福利比較
研究成果報告(精簡版)

計 畫 類 別 ：個別型
計 畫 編 號 ：NSC 95-2415-H-343-002-
執 行 期 間 ：95 年 08 月 01 日至 96 年 07 月 31 日
執 行 單 位 ：南華大學財務管理研究所

計 畫 主 持 人：許鈺珮

計畫參與人員：碩士班研究生-兼任助理：李國安、李承彥、林凱貞、邱柏翰、王國任、曾馨瑩

報 告 附 件 ：出席國際會議研究心得報告及發表論文

處 理 方 式 ：本計畫涉及專利或其他智慧財產權，2 年後可公開查詢

中 華 民 國 96 年 10 月 31 日

行政院國家科學委員會補助專題研究計畫 ■ **成 果 報 告**
□**期中進度報告**

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中　華　民　國　九　十　六　年　十　月　三　十　日

NSC 95-2415-H-343-002 Brief Project Report

A Further Examination of Welfare under Cournot and Bertrand Competition in Differentiated Oligopolies

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Abstract

Häckner (2000) shows that in a differentiated oligopoly with more than two firms and vertical quality differentiation, if quality differences are large and goods are complementary, low-quality firms may charge higher prices under Bertrand competition than under Cournot competition. Hsu and Wang (2005) demonstrates that in Häckner's model, both consumer surplus and total surplus are higher under price competition than under quantity competition regardless of whether the goods are substitutes or complements. This project further examines the welfare comparison by allowing a mixture of substitute and complementary products in a three good model. By considering the effect of the strategic parameter, this project finds that the welfare results of Hsu and Wang (2005) might change under this new angle of consideration.

JEL Classification: D43; L13

Keywords: Welfare; Differentiated Oligopoly; Cournot Competition; Bertrand Competition; Substitutability

1. Introduction

Oligopoly theory has been the skeleton in every economic theorist's closet. There is an old and well-established tradition in economics to represent oligopolistic markets as non-cooperative games. This tradition precedes the formal development of game theory and goes back to the pioneering work of Cournot (1938) followed by those of Bertrand (1883) and Edgeworth (1922). The equilibrium concept in the two classical models in the theory of oligopoly, Cournot and Bertrand models, is the noncooperative equilibrium of Nash (1950). Oligopoly models are referred to as Cournot models if firms compete in terms of their sales or production quantities, and as Bertrand models if they compete in terms of the prices they charges. The work of Singh and Vives (1984) is a classic contribution to oligopoly theory. It discusses the nature of competition in Bertrand and Cournot markets using the duopoly framework developed by Dixit (1979). Singh and Vives (1984) shows that quantities are lower and prices higher in Cournot than in Bertrand competition, and both consumer surplus and total surplus are higher under Bertrand competition than under Cournot competition regardless of whether the goods are substitutes or complements. Furthermore, when goods are substitutes, firm profits are higher under Cournot competition while if goods are complements, Bertrand competition is more profitable. Thus it is a dominant strategy for firms to choose quantity as their strategic variable when goods are substitutes, and prices when they are complements. However, Häckner (2000) shows that in a differentiated oligopoly with more than two firms, prices may be higher under Bertrand competition than under Cournot competition, implying that the classical result of Singh and Vives (1984) that Bertrand prices are always lower than Cournot prices is sensitive to the duopoly assumption. Furthermore, Hsu and Wang (2005) shows that even in Häckner's model, both consumer surplus and total surplus are higher under price competition than under quantity competition regardless of whether the goods are substitutes or complements. Thus Singh and Vives' conclusion on welfare continues to hold in Häckner's oligopolistic model.

A fundamental question in oligopoly model refers to the investigation of monotonicity properties of various performance measures under model's (Nash) equilibrium or equilibria, with respect to specific exogenously specified parameters or strategic instruments. These performance measures include the equilibrium prices charged by the various competitors, their sales or production volumes, their profit margins or the profits achieved in equilibrium. Depending on the application, the strategic instruments may represent capacity levels, wholesale

prices, export subsidies, excise taxes, technology or R&D investments, quality improvements, advertising efforts or inventory service levels, to mention but a few examples. These strategic parameters may have an impact on the demand functions of the various competitors, their cost structures or both.

This project establishes a general linear model where the substitutability parameter is different for each two goods instead of a unique one over the industry to further examine the interesting welfare issue in Hsu and Wang (2005). By considering the impact of this strategic parameter allowing a mixture of substitute and complementary products, we work on a three good model and do some extensive computer simulations to see if the welfare results of Hsu and Wang's (2005) still hold for all possible parameter values. We investigate the monotonicity property of the consumer surplus and total surplus for oligopoly model with general-linear cost function and general dependencies of the cost and demand functions on the strategic substitutability parameters under consideration.

2. Literature Review

Ever since Bertrand's well-known criticism of Cournot's homogeneous-product duopoly model, it has been widely held, often unconditionally, that price competition is more competitive than quantity competition. The intuitive explanations typically refer, in one form or another, to the fact that, for substitute or complementary goods, "firms have less capacity to raise prices above marginal cost in Bertrand competition because the perceived elasticity of demand of a firm when taking the price of the rival as given is larger than that which the firm perceives when taking the quantity of the rival as given" (Singh and Vives, 1984). This makes Bertrand firms more eager to lower prices than Cournot firms to increase quantities, thereby leading to a more competitive outcome under price competition. Amir and Jin (2001) also provides support for the conventional wisdom that Bertrand equilibrium is indeed more competitive than Cournot equilibrium according to three criteria: lower mark-up/outputs ratios, larger average output, and lower average price.

Hathaway and Rickard (1979) shows that in a duopoly with general demand and substitute goods, at least one firm's price is higher and one output is lower in Cournot equilibrium. Singh and Vives (1984) conclude that in a linear duopoly with differentiated products (substitutes or complements), both firms' prices are lower while quantities and social welfare are higher in price competition. Cheng (1985) also obtained similar results using a geometric approach. Vives (1985)

uses an oligopoly model with a general demand function and substitute goods, and finds that prices are higher and quantities smaller in Cournot than in Bertrand competition. While under strategic complementarity of prices and quasi-concavity of profits in own price, for any Cournot equilibrium price, there is a Bertrand equilibrium with lower prices for all firms. Okuguchi (1987) dispense with symmetry and product substitutability, and shows that the unique Bertrand price vector is lower than any Cournot equilibrium price vector if, in addition, the product set can be partitioned into two subsets in such a way that products are substitutes within each subset and complements across subsets. Furthermore, he also shows that if prices are strategic substitutes instead, at least one equilibrium price is lower in the Bertrand case. Finally, he provides a counterexample of a symmetric duopoly with linear demand for two complementary goods, and exhibits lower prices and higher outputs in the Cournot case. Häckner (2000) considers an n-firms differentiated goods oligopoly model with quality differentiation that is a direct generalization of the duopoly model developed by Dixit (1979). He shows that prices may be higher under price competition than under quantity competition if quality differences are large and goods are complements. If goods are substitutes, high-quality firms may earn higher profits under price competition than under quantity competition. Hsu and Wang (2005) demonstrates that both consumer surplus and total surplus are higher under price competition than under quantity competition regardless of whether the goods are substitutes or complements, which answers the important question of whether welfare may be lower under price competition left by Häckner's. While switching from Cournot to Bertrand competition, all firms with above average quality levels obtain larger output shares with the highest quality firm gaining the most in share and all firms with below average quality levels receive smaller output shares with the lowest quality firm losing the most in share. Thus low-quality firms have insignificant effects on the overall welfare although their Bertrand price may be higher.

A fundamental question in oligopoly model refers to the investigation of monotonicity properties of various performance measures under model's (Nash) equilibrium or equilibria, with respect to specific exogenously specified parameters or strategic instruments. These strategic parameters may have an impact on the demand functions. The class of supermodular games represents a general framework under which the existence of an equilibrium is guaranteed and general conditions can be specified to ensure that the equilibrium is monotone with respect to one or several input parameters. A game is called supermodular if

each of the action sets of the players is compact and the increment in any of the players' profits due to an increase in one of its action variables, is increasing in any other action variable, whether its or that of a competitor. Topkis (1998) or Vives (2000) exhibit monotonicity results for optimal actions or equilibria, which have an explicit or implicit foundation in properties of supermodular functions on lattices. However, other types of comparative statics in oligopoly models are relatively little, such as the equilibrium being monotone in specific input parameters.

In this project, we establish a general linear model where the substitutability parameter is different for each two goods instead of a common one among all firms in Hsu and Wang (2005) to further examine the interesting welfare comparison issue. While most of the previous literatures focus on the competitiveness comparison of equilibrium prices and quantities, we attempt to provide additional insight into the welfare comparison issue. By considering the impact of the strategic parameter, we allow a mixture of complementary and substitute goods such that neither prices nor quantities are strategic complements. We work on a three good model and do some extensive computer simulations to see if the welfare results of Hsu and Wang's (2005) still hold for all possible parameter values.

3. Result and Discussion

In our project, we follow closely the procedure considered in Hsu and Wang (2005). We use a differentiated oligopoly with more than two firms and vertical quality differentiation. However, we allow a mixture of complementary and substitute goods such that neither prices nor quantities are strategic complements. Therefore, we include different substitutability parameters for each two goods instead of a common one as in Hsu and Wang (2005). That is, we have parameter γ_{ij} between good i and good j instead of a general γ for all goods. To address this different specified issue, there is a representative consumer in our model with the following quasi-linear utility function:

$$U(q,I) = \sum_{i=1}^{n} a_i q_i - \frac{1}{2}(\sum_{i=1}^{n} b_i q_i^2 + 2\sum_{i \neq j} \gamma_{ij} q_i q_j) + I \qquad (1)$$

In (1), $\mathbf{q} = (q_1, \cdots, q_n)$ is the quantity vector with each q_i denoting the consumer's consumption of good i; $a_i > 0$; $b_i > 0$; $\gamma_{ij} \in [-1,1]$ is the substitution parameter between good i and good j ($\gamma_{ij} = \gamma_{ji}$); good i and j are substitutes, independent, or

complements according as $\gamma_{ij} > 0$, $= 0$, or < 0. I is a composite measure of the consumer's consumption of all other goods.

Let p_i denote the price of good i, m the consumer's income, and the composite good's price be normalized to 1. Maximizing U(**q**, I) subject to the budget constraint that $\sum_{i=1}^{n} p_i q_i + I \le m$ gives the inverse demand equations:

$$p_k = a_k - b_k q_k - \sum_{j \neq k} \gamma_{kj} q_j , \quad k = 1,\ldots,n. \tag{2}$$

We then use a three good model to simplify the computation of the equilibria and welfare valuation. By considering all possible strategic substitute parameter values, the simulation results show that the welfare outcomes of Hsu and Wang (2005) might change by allowing a mixture of substitute and complementary products in the model. Thus, the strategic parameter does have an impact on the welfare comparison.

4. Conclusion and Self-Evaluation of the Project

In this project, we further examine the interesting welfare comparison issue by establishing a general linear model where the substitutability parameter is different for each two goods instead of a common one among all firms as in Hsu and Wang (2005). The simulation results of the three good model with different values of γ_{ij} demonstrate different welfare outcomes from those in Hsu and Wang (2005), implying that Hsu and Wang's results on consumer surplus and producer surplus are sensitive to the unique setting of the strategic parameter. This new angle of consideration in this project may contribute a very interesting point to related literature and future research.

This project has closely followed the procedure and achieved the results as we planned and anticipated in the earlier proposal. It provides useful outcomes and could be further polished to submit to a SSCI journal in the near future.

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出席國際學術會議心得報告

計畫編號	95-2415-H-343-002-
計畫名稱	再探異質寡占市場中數量競爭與價格競爭之福利比較
出國人員姓名 服務機關及職稱	許鈺珮 南華大學財管所助理教授
會議時間地點	2007 年 1 月 12 日–1 月 14 日 大陸北京
會議名稱	（中文）美國西部國際經濟學會 2007 年太平洋盆地年會 （英文）2007 WEAI Pacific Rim Conference
發表論文題目	（中文）台灣金融控股公司之經營績效衡量 （英文）Performance Assessments of Taiwan's Financial Holding Companies

一、參加會議經過

晚學於九十六年一月十一日於高雄啟程前往香港轉機至北京，並於一月十二日上午於大會（北京大學) 發表論文 "Performance Assessments of Taiwan's Financial Holding Companies"。此次會議全部議程於一月十四日圓滿結束，因航班安排，晚學於一月十五日返台。會議期間所參加數場演講之心得摘要如下。

二、與會心得

晚學於此次會議參加之論文場次包括:

[6] Financial institutions in China and Taiwan
[7] Industry Level Performance
[17] FDI, Technology, and Trade
[26] FDI to and from Developing Countries
[36] Trade and Economics of China
[ ]表大會之場次號碼

依場次號碼順序，將簡要心得分述如下。

[6]

Financial Institutions in China and Taiwan

1. Performance Assessments of Taiwan's Financial Holding Companies
2. Enlarge Financial Support of China's West Development via Financial Inventions
3. The Reform and Effect of Grass Roots Financial Institutions in China

本場次由來自 NERA Economic Consulting 之 Dr. Gregory K. Leonard 主持，論文

發表人除了晚學外，另兩篇論文之作者分別為中國人民大學及蘭州大學的教授，但不知何故此兩篇論文作者都未到場，故只有晚學發表第一篇論文，內容主要是利用風險值及風險調整資本報酬率來探討台灣的金融控股公司在成立前後的風險涉險程度與經營績效表現，評論人即是 Dr. Leonard，其與其他與會之先進提供了晚學許多寶貴之意見。

[7]

Industry Level Performance

1. Measuring the substitution effects of sales promotions in supermarkets: an analysis based on a dynamic model of differentiated products (Fei Deng)
2. The impact of e-commerce strategies on "pure play" internet bank's value
3. Market share, price and profit in OECD mobile telephone markets (Nakil Sung)
4. Domestic imitative threats and high-tech imports: evidence from Taiwan

此場次由 NERA Economic Consulting 之 Dr. Fei Deng 主持，Dr. Deng 為美國波士頓大學經濟學博士 (2006 年 6 月)，此次發表之論文為以差異性產品之動態模型衡量超級市場番茄醬促銷時之替代效果，此類題目為最近研究產業組織熱門之議題。第二篇論文原定由亞洲大學國際企業系呂承璋助理教授發表，但呂教授因故未能參加此次會議，故取消其論文發表。來自韓國之 Dr. Nakil Sung 發表本場次第三篇論文，Dr. Sung 為首爾市立大學 (University of Seoul) 之經濟系教授，專長為電信產業之實證研究，曾發表論文於 *Review of Economics and Statistics*、*Review of Industrial Organization*、*Economic Inquiry*、*Contemporary Economic Policy*、*Telecommunications Policy* 及 *Applied Economics*。第四篇論文則由中正大學經濟系教授 Dr. Wen-Hsien Liu 發表，探討台灣高科技產品進口是否會受到台灣專利權保護程度影響，由 Dr. Deng 評論。

[17]

FDI, Technology, and Trade

4. Endogenous product vs. process innovation and a firm's propensity to export
5. The impact of going multinational on domestic investment
6. A new look at FDI and wages

本場次由來自聯合國貿易暨發展會議 (United Nations Conference on Trade and Development, UNCTAD) 之 Dr. Masataka Fujita 主持，三篇論文發表人皆來自歐洲同一研究團隊，包括德國慕尼黑大學的 Dr. Peter Egger、Dr. Sascha Becker 及瑞典斯德哥爾摩大學之 Dr. Karolina Ekholm，其中又以曾發表兩篇有關國際貿易引力模型修正的論文之 Dr. Egger 最為有名。由其發表之論文品質可見此世界級團隊在相關議題之研究水準。

[26]

FDI to and from Developing Countries

1. How reliable are FDI data? Lessons from World Investment Reports
2. Inward FDI and export comparative advantage
3. Outward FDI from developing countries: implications for development
4. Chinese data on FDI

本場次由 Dr. Sascha Becker 主持，並由其研究團隊擔任此四篇論文之評論人，論文依序由 Dr. Masataka Fujita (UNCTAD)、Dr. Jing Sun (City University of New York)、Gouyong Liang (UNCTAD)及 Yuan Dong (Ministry of Commerce, China) 發表，主要在探討 FDI 資料之可靠性。

[36]

Trade and Economics of China

1. Productivity and foreign direct investment in China: a panel data study for 1992-2004
2. An empirical study of the pass-through effect on China's trade prices
3. Was China the first domino? Revisiting the Asian Crisis
4. Is foreign direct investment productive in the Latin American case? A panel unit root and panel cointegration analysis

本場次由 Dr. Jack Hou (California State University, Fullerton) 主持，Dr. Hou 之父親為國內著名之經濟學家--前東吳大學經濟系系主任侯家駒博士。本場次前三篇論文皆探討貿易與外人直接投資對中國經濟的影響，第四篇則探討拉丁美洲國家生產力如何受到外人直接投資的影響。

Performance Assessments of Taiwan's Financial Holding Companies

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Abstract

This paper uses Risk-Adjusted Return on Capital (RAROC) to assess the performance of 14 financial holding companies (FHCs) in Taiwan. We use the full valuation methods to calculate Value at Risk (VaR) as the market risk measurement for economic capital. According to the New Basel Capital Accord, the market risk of Internal Model should be adjusted, and the Bank for International Settlement suggests use the backtest to select the best full valuation method for estimating adjusted VaR. Therefore, this paper evaluates the best market risk model, and assesses and compares the performance for each firm before and after its merger and acquisition into the FHC.

JEL classification: G23; G34

Keywords: Financial Holding Company (FHC); New Basel Capital Accord; Market risk; Value at Risk (VaR); Risk-Adjusted Return on Capital (RAROC)

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1. INTRODUCTION

The world is traveling at a lot faster pace then it did thirty years ago. In recent years, many countries have become more closely integrated into the global financial system. In order to encourage economic growth and stimulate market competition, the increase in financial liberalization and deregulation has reduced financing constraints, and the wave of mergers and acquisitions has contributed to the appearance of large financial institutions, such as financial holding companies. However, the financial globalization and freedom also expanded the risk and instability in the international market.

According to Risk Management Guidelines for Derivatives announced by Basel Committee on Banking Supervision of Bank for International Settlements in 1994, financial institutions are allowed to apply Value at Risk (VaR) to measure their market risk exposure. Furthermore, the Amendment to the Capital Accord to Incorporate Market Risk in 1996 clearly introduced internal models for measuring market risks as an alternative to a standardized measurement framework originally put forward in April 1993. In order to ensure a minimum degree of prudence, transparency and consistency of capital requirements across banks, the Committee proposed a number of quantitative and qualitative criteria for those banks which wish to use proprietary models.

The use of proprietary in-house models to measure market risk for supervisory capital purposes represents a significant innovation in supervisory methods. Moreover, many internationally active banks are themselves in the process of gaining experience with the use of risk measurement and management techniques based on the value-at-risk approach. In order to gain additional information and comfort with the results produced by internal models, supervisory authorities reserve the right to require banks wishing to use internal models to perform testing exercises and to provide any other information necessary to check the validity of banks' models.

In 2004, the New Basel Capital Accord was introduced by Basel Committee on Banking

Supervision of Bank for International Settlements to preserve the integrity of capital in banks with subsidiaries and also extend to holding companies that are parents of banking groups. As shown in table 1, the main goal is to reinforce the risk management system within the banking industry by the three pillars of “minimum capital requirements,” “supervisory review” and “market discipline.” The first pillar, “minimum capital requirements,” includes three methods for measuring credit, operational and market risks, and provides the Standardized Approach and the Internal Modeling Approach for selection and utilization of banks; besides, with respect to the second pillar, supervisory review, the supervisory agency will assess risk management ability of banks through a review procedure, and if the risk management ability of a bank is found to be unsatisfactory, the supervision institute will request the bank to increase and reserve capital; and banks shall conduct more public disclosure of qualitative and quantitative information for capital and risk management in accordance with regulations of the third pillar, market discipline, which means risk management strategies and execution quality of the bank will also be the focal point of supervision in the future, and face check and balance imposed by market functions.

Taiwan's economy grew at a phenomenal pace throughout the 1970s and 1980s. The rapid accumulation of assets that accompanied this growth led to a tremendous increase in financial activity and brought about profound structural changes in the local financial markets. Increasing labor costs and the appreciation of the NT dollar in the 1980s sped up the globalization of Taiwanese capital by encouraging investments and other financial involvement in overseas financial markets. This trend, in turn, exerted competitive pressure on the domestic financial system and forced Taiwan to liberalize itself more to attract foreign investors and financial institutions.

Taiwan has strengthened financial re-regulation and supervision in response to changes in the financial environment. The rapid expansion of financial markets, including the

deregulation of financial activities, financial innovations, and new entries in the financial sector, as well as the possible disorder associated with financial realignment, have all made re-regulation necessary. In line with the Bank of International Settlements, Taiwan has set its capital adequacy ratio at 8 percent of risk assets. The Banking Act of 1989, while allowing new entrants into the banking industry, also tightened regulations dealing with problematic banks. Regulating some areas while deregulating others has been the most important task of financial restructuring in Taiwan.

Though the Financial Holding Company Act in 2001 permits banks, securities firms and insurance companies to affiliate in Taiwan, the influence and performance of those financial holding companies (FHCs) after restructuring in the capital market hasn't been discussed rigorously yet. Former performance investigations most use two index: Return on Asset (ROA) and Return on Equity (ROE). ROA uses asset value and ROE uses equity value to evaluate firm performance. However, these two methods do not consider the risk influence very careully. Therefore, the new Risk-Adjusted Return on Capital (RAROC) introduced by Bankers Trust seems to be a better approach to measure the performance for financial institutions since it includes the concept of VaR to assess the risk-adjusted capital allocation.

To make the capability of Taiwan's domestic banks in capital adequacy management and risk management meet international standards, the Financial Supervisory Commission of the Executive Yuan (the FSC) already sent a letter to notify domestic banks on September 21, 2004 that the Government will amend Taiwan's "Administrative Rules of Capital Adequacy for Banks," "Explanations for Methods of Calculating Self-Contained Capital and Risk-Based Assets of Banks" and other rules with reference to international regulations. The FSC expects to officially implement the New Basel Capital Accord at the same pace with the world as of year-end 2006, so it urges banks to plan related measures to cope with the New Basel Capital Accord in advance, as well as set up a well-arranged risk management mechanism, to ensure legal compliance and increase competitiveness.

Since the synergy of the FHCs in Taiwan is of highly interest and worth of investigation, and the risk management and capital adequacy issue is very important according to the New Basel Capital Accord, this paper focuses on the market risk of 14 FHCs by measuring their VaRs under different models, and selects the most appropriate VaR model for each firm by applying the Kupiec backtest. Moreover, we calculate the RAROC of each FHC, and compare its risk management ability and firm performance before and after its merger and acquisition into the current FHC. The results show that some of the FHCs indicate better performance because of their risk management improvement compared to their primary companies[1].

2. LITERATURE REVIEW

According to the New Basel Capital Accord, the market risk could be measured by Internal Models Approach (Table 1), and VaR is the indicator to evaluate the market risk in internal model. The Basel Committee on Banking Supervision also suggested use backtest with VaR in order to make the accurate estimation. The internal models methodology for measuring exposure to market risks is based on the following general conceptual framework. Price and position data arising from the bank's trading activities, together with certain measurement parameters, generates a measure of the bank's market risk exposure, typically expressed in terms of VaR. This measure represents an estimate of the likely maximum amount that could be lost on a bank's portfolio with a certain degree of statistical confidence. It is therefore specifying that all banks using the models approach employ at least a ten- day holding period, one-year historical sample period, and a 99% one-tailed confidence interval. A confidence level of 99% means that there is a 1% probability based on historical experience that the combination of positions in a bank's portfolio would result in a loss higher than the measured value-at-risk. In doing so, they were asked to produce a total VaR figure, as well as

[1] Primary company means the original company that conducts the merger and acquisition activity into the establishment of the financial holding company.

individual VaR figure for foreign exchange, interest rate and equity risk categories and also to test four different variants of the portfolio, one balanced and one unbalanced, each with and without options positions.

Jorion (2000) indicates that VaR generally can be classified into two broad methodologies: delta-normal method based on local valuation, and historical-simulation method, bootstrap method, and Monte Carlo simulation method implemented as full valuation. The delta-normal method is ideally suited to large portfolios exposed to many risk factors. However, it suffers from several problems, such as the worst loss may not be obtained for two extreme realizations of the underlying spot rate, etc. From the full distribution of potential outcomes, VaR can be calculated using the actual percentiles of distributions. Full valuation must be employed to evaluate the risk exposed to a limited number of sources of risk. Full valuation approach requires computing the value more correctly in theory. Thus our paper employees the full valuation methods to calculate Value at Risk (VaR) as the market risk measurement.[2]

Kupiec (1995) introduces the Kupiec backtest, which is perhaps the most widely used frequency-of-tail-losses test. The idea behind this approach is to test whether the observed frequency of tail losses (or frequency of losses that exceed VaR) is consistent with the frequency of tail losses predicted by the model. The null hypothesis is that the model is good. Dowd (2005) mentions that the results of the backtests are used by supervisors to assess financial institutions' market risk models, and to determine the multiplier factor to be applied. If the number of exceptions during the previous 250 days is less than 5, then the multiplier is 3; if the number of exceptions is 5, the multiplier is 3.40, and so forth; and 10 or more exceptions warrant a multiplier of 4.

James (1996) describes the development of the RAROC methodology began in the late

[2] Please see Garbade (1986), Bender (1995), Duffie and Pan (1997) and Venkataraman (1997) for more discussions on VaR.

1970s, initiated by a group at Bankers Trust. Their original interest was to measure the risk of the bank's credit portfolio, as well as the amount of equity capital necessary to limit the exposure of the bank's depositors and other debtholders to a specified probability of loss. Since then, a number of other large banks have developed RAROC or (RAROC-like systems) with the aim, in most cases, of quantifying the amount of equity capital necessary to support all of their operating activities -- fee-based and trading activities, as well as traditional lending. Bank of America's policy is to capitalize each of its business units in a manner consistent with an AA credit rating, based on the unit's "stand-alone" risk, but also including an adjustment for any internal diversification benefits provided by the unit. Each of these individual capital allocations are then aggregated to arrive at the optimal level of equity capital for the entire bank.

RAROC systems allocate capital for two basic reasons: (1) risk management and (2) performance evaluation. For risk-management purposes, the overriding goal of allocating capital to individual business units is to determine the bank's optimal capital structure. This process involves estimating how much the risk (volatility) of each business unit contributes to the total risk of the bank and, hence, to the bank's overall capital requirements. For performance-evaluation purposes, RAROC systems assign capital to business units as part of a process of determining the risk-adjusted rate of return and, ultimately, the economic value added of each business unit. The economic value added of each business unit, defined in detail below, is simply the unit's adjusted net income less a capital charge (the amount of equity capital allocated to the unit times the required return on equity). The objective in this case is to measure a business unit's contribution to shareholder value and, thus, to provide a basis for effective capital budgeting and incentive compensation at the business-unit level.

Zaik et al. (1996) points out the use of RAROC by major money-center and regional bank to formulate capital structure targets and to evaluate performance is a major departure from traditional practice. Bankers have long relied on measures such as ROA and ROE to

evaluate their own performance, both at the consolidated level and for individual operating units. The calculation of RAROC is relatively simple once all the risk calculations have been completed. RAROC is computed by dividing risk-adjusted net income by the total amount of economic capital assigned based on the risk calculation. This approach served two purposes. First, it allowed early testing of the framework's ability to be adapted to a variety of different kinds of portfolios and businesses. Second, and perhaps more important, this approach greatly increase the level of information about and acceptance of the concept within the organization.

Dowd (2000) proposes a new rule for risk adjustment and performance evaluation. This rule is a generalization of well-know Sharpe ratio criterion, and under normal conditions enables a manager to correctly assess alternative risky investments. It is superior to the standard Sharpe ratio because it is valid regardless of the correlations of investments being considered with the rest of the portfolio. Some illustrative numerical examples also suggest that generalized and traditional Sharpe rules can generate very different required returns and hence lead to very different decision.

3. ANALYTICAL FRAMEWORK

3.1 Empirical Model and Methodology

We first estimate the rate of market return and the rate of stock return by taking logarithm of daily closing index of Taiwan Weighted Stock Index and daily closing price of each firm's stock. The calculation of the rate of return for each FHC and primary company also follows the same way. We then use the Augmented Dickey-Fuller (ADF) unit root test to examine if these returns are stationary series. When the series is nonstationary, differentiation is required to make the series stationary to avoid the problem of spurious regression. We next turn to use the Ljung-Box Q test to examine if the residual of rate of return has the first or higher order autocorrelation that will result in inconsistent parameter estimations. If there is no autocorrelation, then we construct the ARMA(p, q) model for each FHC and primary

company. Moreover, if the residual has an ARCH effect, then the estimated coefficients are ineffective. A *LM* test is therefore implemented to test if an ARCH effect exits. Once the ARCH effect is confirmed, then a GARCH model is considered. On the other hand, the ARMA(p, q) model is used when there is no ARCH effect.[3]

We apply both VaR and RAROC models into our analytical framework. The VaR model is mainly used in this paper to measure the market risk. We adopt three VaR methods in this paper as the Internal Models Approach in the first pillar of the New Basel Capital Accord to measure the market risk and use the Backtest to find the optimal VaR value for each FHC and primary company. The RAROC model, on the other hand, is used as a tool of performance assessment. We extend its application in this paper based on the foundation made by the previous studies.

The key to a successful estimation of the VaR model is the loss-profit distribution plot of the risky investment portfolio during the evaluation period, while an accurate estimation of portfolio risk can be obtained only when the assumptions of different VaR methods are fully understood. Below follows a brief introduction on the three VaR methods.

(1) Historical Simulation Method

Historical simulation method calculates the portfolio risk based on the historical data. It uses the historical price series of holding assets in a specific period of time with their current positions to construct the distribution of asset returns in the future. By sorting the return values from small to large, the VaR values under a specific confidence level can be obtained based on the percentile (Hendricks, 1996). This method assumes that the future trend of returns will follow the past, thus the number of historical data must be large enough to approximate the true situation in the past and to simulate a meaningful distribution of returns in the future. The simulation is conducted by the following steps: 1) calculating the change

[3] Please see Engle (1982) and Bollerslev (1986) for discussions on ARCH.

in the asset price by using the historical price of the holding portfolio investment asset, and 2) adding current asset value to simulate the future price for each asset, 3) sorting the simulation value of future return from small to large to obtain the VaR value based on the percentile, given a specific confidence level.

(2) Bootstrap Method

The estimation of the bootstrap method can be conducted by building the statistical distribution using the repeated samplings from a selected set of historical data without knowing the distribution of parameters (Efron, 1979). The use of the nonparametric randomization technique to simulate more samples can overcome the problem of data shortage. Its simulation procedure is as same as the historical simulation method.

(3) Monte Carlo Simulation Method

Monte Carlo simulation method not only can cover all possible occurrences of variables, but also can deal with non-normal distribution. There are two major steps in applying the Monte Carlo simulation method to estimate the VaR value: 1) choosing the random model of price behavior, and 2) using Random Number Generator to repeatedly simulate the asset price to obtain the probability distribution of price. In this paper, we choose Geometric Brownian Motion (GBM) to portray the process of stock price variation. Equations (1) to (3) show the GBM model applied in Monte Carlo simulation method:

$$ds_t = u_t s_t d_t + \sigma_t s_t d_z \quad (1)$$

$$d_z \sim N(0, d_t) \quad (2)$$

$$d_z = \varepsilon \sqrt{d_t} \quad (3)$$

where *dz* is a normal random variable distribution, *dt* is the change of time period, μ_t is a drift term, σ_t is the variance which is also the risk parameter. In order to simulate the probability

distribution of asset price (S_t), we can generate $\varepsilon_1,...,\varepsilon_n$ by Random Number Generator under standard normal distribution, $N(0, 1)$, to find the probability distribution of asset price.

After obtaining the VaR value, we use backtest to find the optimal VaR model for each FHC. To avoid the underestimation of VaR value, we follow the suggestion made by the Basel Bank Governance Committee in 1996 and use Kupiec (1995) model as our backtest. From the number of failure in the estimation result, we can identify the efficiency and the accuracy of a VaR model. Therefore, we use the number of failure as a selection criterion to decide the optimal VaR model for each FHC and primary company. The model is as follows

$$\Pr\left(x\middle|n, p\right)=\binom{n}{i}p^{i}\left(1-p\right)^{n-i} \tag{4}$$

where x is the number of failure, p is the significance level, and n is the sample size.

After selecting the optimal VaR model for each FHC and primary company by the backtest, the VaR value obtained can be used as the denominator of RAROC. Once the nominator and the denominator are known, we can obtain the RAROC value as a standard of performance assessment. According to Prokopczuk, Rachev, Schindlmayr and Trück (2005), RAROC is defined as

RAROC = (Expected Return) / (Economic Capital) (5)

Economic capital is usually defined as the capital that a bank must prepare to prevent the bankruptcy. Since the VaR value is used to measure the possible loss during a specific period of time under a confidence level, the estimation of economic capital is the same as the estimation of VaR in principle. Therefore, we use the VaR value as a proxy of economic capital in this paper. We also define the expected return as the corporate return subtracted by the market return. When dividing the expected return by the VaR value, the RAROC value is obtained as follows

RAROC = (Expected Return) / (VaR)

= (Corporate Return – Market Return) / (VaR) (6)

When estimating the expected return, we adopt the Market Model which is based on the Capital Asset Pricing Model (CAPM) as follows

$$Y_{it} = \alpha_i + \beta_i RM_t + \varepsilon_{it} \quad (7)$$

where Y_{it} denotes the return of company *i* in time *t*, RM_t is the market return in time *t*.

Because the data used in this paper are the time series data, we need to consider the problem of autocorrelation and hetroskdasticity. Besides, the assumptions of the Market Model are not consistent with the real market behaviors, such as ε_{it} and RM_t are not related and $E(\varepsilon) = 0$. Hence, we decide to release the assumptions step by step by considering the autocorrelation problem and that ε_{it} and RM_t are possibly related and $E(\varepsilon) = 0$ might not be true. We estimate the expected return for each company according to their data characteristics. If there is an ARCH effect, then we apply the ARMA-ARCH estimation to calculate the difference between the corporate return and the market return and use the difference as the expected return

$$Y_t = C + \sum_{i=1}^{n} \alpha_i Y_{t-i} + \varepsilon_t + \sum_{j=1}^{m} \beta_j \varepsilon_{t-j} + \sum_{k=0}^{p} \gamma_k RM_{t-k} \quad (8)$$

$$\sigma_t^2 = c + \sum_{i=1}^{m} \phi_i \sigma_{t-i}^2 + \sum_{j=1}^{n} \varphi_j \varepsilon_{t-j}^2 \quad (9)$$

where Y_t denotes the corporate return of company *t* and RM_t denotes the market return after company *t* complete the time-adjustment. If there is no ARCH effect, then the estimation follows an ARMA model.

3.2 Data Sources

The 14 FHCs and their primary companies studied in this paper are listed in Tables 2 and 3 with their established and sample periods. The data are collected from Taiwan Economic Journal (TEJ) database. We choose the daily closing price as our price data since it is the price with full information disclosure. The sample period for each FHC and primary company is decided by the establish date of each FHC. The sample period for a FHC is the

first three years after the FHC is established and the sample period of a primary company is the last three years before its FHC is established. The estimation period of the market return is also adjusted according to the launch date of each FHC.

4. EMPIRICAL RESULTS

4.1 Results from the tests

The results from the ADF unit root test (not reported here) indicate that all FHC and primary company pass the unit root test after the first differentiation. The results from the Ljung-Box *Q* test (not reported here) also conclude that no autocorrelation is found in the ARMA model of any FHC and primary company. We further test if there is an ARCH effect under 5% significance level. The result (not reported here) shows that, among the primary companies, China Development Industrial Bank, Chinatrust Bank and First Bank does not reject the null hypothesis which is no ARCH effect. Thus, these three companies can use ARMA model to estimate the parameters and others need to use GARCH model in their estimation. Among FHCs, except Waterland Holdings, SinoPac Holdings, FuHwa Holdings and Jih Sun Holdings, others do not have the ARCH effect and can be estimated by the ARMA model.

4.2 Results from the empirical model

Tables 4 and 5 report the estimated VaR values for each FHC and primary company at 1% significance level by using three different VaR methods. Tables 6 and 7 provide detailed results on Kupiec Backtests which are used to decide the optimal VaR model for each FHC and primary company. For primary companies, most companies fits in the Monte Carlo simulation method, except Huana Bank, Fubong Insurance, Cathay Life, Chiao Tung Bank and Bank SinoPac which are better portrayed by the historical simulation method. However, the bootstrap method does not work for any primary company. On the other hand, for FHCs,

the bootstrap method works for Fuhwa Holdings, Mega Holdings, Jih Sun Holdings and First Holdings and the historical simulation method works for Fubong Holdings and Waterland Holdings. Others fit in the Monte Carlo simulation method.

From Tables 8 and 9, we observe that First Bank and Mega Holdings outperform other primary companies and FHCs in terms of risk-adjusted return, while Cathy Life and China Development Holdings are the worst among primary companies and FHCs. The primary companies and FHCs with negative risk-adjusted returns are those whose corporate return does not exceed the market return. Their expected return is lower than the market return, thus their performance are far from satisfying the investors.

RAROC represents the excess return for each unit of risk. When the RAROC value is larger, it means the excess return is higher. RAROC is calculated from the expected return divided by VaR. Before taking VaR as the denominator, VaR needs to be adjusted according to the number of failure. According to the suggestion made by the New Basel Capital Accord, the adjustment multiplier is 3 when holding period is one year (250 days) and the number of failure is less than 5; once the number of failure excess 5, then the adjustment multiplier raises to 3.4; when the number of failure exceeds 10, the adjustment multiplier is 4 and the risk estimated from the model is highly underestimated. Because the sample period of our study is three years (750 days), the number of failure should be expanded to three times, i.e. when the number of failure is less than 15, the multiplier is 3; once the number of failure exceeds 15, the multiplier is 3.4; when the number of failure is more than 30, the multiplier raises to 4. Since the number of failure in the optimal VaR model for each FHC and primary company is below 15, we use 3 as the multiplier.

Tables 10 and 11 report the RAROC values for primary companies and FHCs, respectively. For primary companies, the best performer in the past three years is Taishin Bank, the worst is Cathy Life. If we use the VaR value to decide the market risk, Chinatrust Bank has the largest risk variation and Jih Sun Bank has the least. For FHCs, Mega Holdings

is the best performer and China Development Holdings is the worst. Huanan Holdings suffers the highest risk variation and Chinatrust Holdings enjoys the least.

5. CONCLUSIONS

This paper uses the Internal Models Approach mentioned in the New Basel Capital Accord to measure the market risk of 14 FHCs and their primary companies, and selects the most appropriate VaR model for each firm by applying the Kupiec backtest. Moreover, we calculate the RAROC of each FHC and its primary firm, and compare its risk management ability and firm performance before and after its merger and acquisition into the current FHC.

From Tables 10 and 11, for primary companies, Chinatrust Bank has the largest market risk variation and Jih Sun Bank has the least according to the VaR values. For FHCs, Huanan Holdings suffers the highest risk variation and Chinatrust Holdings enjoys the least. Among the 14 FHCs, 6 of them have lower market risk compared to their primary companies, including Chinatrust Holdings, First Holding, Waterland Holdings, Mega Holdings, Fuhwa Holdings, and Fubong Holdings, which shows the risk diversification effect after the merger and acquisition.

While we look at the expected return of each primary company and each FHC in Tables 10 and 11, it measures firm's performance before any risk adjustments. However, RAROC value indicates firm's performance after considering the market risk effect, and gives better measurement of firm's operational performance. Thus the order of some firms' performance according to the RAROC results has changed, and is different from that of the expected return results.

In accordance with the RAROC values, for primary companies, the best performer is Taishin Bank, the worst is Cathy Life. For FHCs, Mega Holdings is the best performer and China Development Holdings is the worst. Among the 14 FHCs, 6 of them have better performance than heir primary companies, such as Chinatrust Holdings, Waterland Holdings,

Mega Holdings, Huanan Holdings, SinoPac Holdings, and Cathay Holdings, which indicates better affiliation and synergy effect after the merger and acquisition.

This paper investigates the performance before and after the establishment of 14 FHCs in Taiwan. Due to the limitation of sample period studied, the performances of most companies are not as good as expected. Besides, we only discuss the market risk of the New Basel Capital Accord by estimating the VaRs. Furthermore, we focus on the ex post performance evaluation instead of the ex ante risk management analysis. Therefore, future studies can assess other types of risks, such as credit risk and operational risks, to compare the risk management ability and performance of FHCs and primary companies in a longer period.

Table 1 The New Basel Capital Accord

three pillars		risk	measurement methodology
First Pillar	Minimum capital requirement: the minimum ratio of capital to risk weighted assets	credit risk	Standardized Approach Fundamental Internal Ratings Based Approach Advanced Internal Ratings Based Approach
		market risk	Standardized Approach Internal Models Approach
		operational risk	Standardized Approach Basic indicator Approach Advanced Measurement Approach
Second Pillar	Supervisory review process: supervisory transparency and accountability, and risk management guidance with bank risks, including guidance pertaining to the treatment of interest rate risk in the banking book		
Third Pillar	Market discipline: disclosure requirement for regulatory purposes		

Table 2 Sample period for each financial holding company

financial holding company	date established	sample period
Huanan Holdings (	2001/12/19	2001/12/19～2004/12/17
Fubong Insurance	2002/12/31	2002/12/31～2005/12/31
Cathay Holdings	2002/12/19	2002/12/19～2005/12/19
China Development Holdings	2001/12/28	2001/12/28～2004/12/28
E. Sun Bank	2002/01/28	2002/01/28～2005/01/28
Fuhwa Holdings	2002/02/04	2002/02/04～2005/02/04
Mega Holdings	2002/02/04	2002/02/04～2005/02/04
Taishin Holdings	2002/02/18	2002/02/18～2005/02/18
Shin Kong Holdings	2002/02/19	2002/02/19～2005/02/19
WaterLand Holdings	2002/03/26	2002/03/26～2005/03/26
SinoPac Holdings	2002/05/09	2002/05/09～2005/05/09
Chinatrust Holdings	2002/05/07	2002/05/07～2005/05/07
First Holdings	2003/01/02	2003/01/02～2006/01/02
Jih Sun Holdings	2002/02/05	2002/02/05～2005/02/05

Table 3 Sample period for each primary company

primary company	sample period	financial holding company
Huanan Bank	1998/12/19～2001/12/19	Huanan Holdings
Fubon Insurance	1999/12/31～2002/12/31	Fubong Holdings
Cathay Life	1999/12/19～2002/12/19	Cathy Holdings
China Development Industrial Bank	1998/12/28～2001/12/28	China Development Holdings
E. Sun Bank	1999/01/28～2002/01/28	E. Sun Holdings
Fuhwa Securities	1999/02/04～2002/02/04	Fuhwa Holdings
Chiao Tung Bank	1999/02/04～2002/02/04	Mega Holdings
Taishih Bank	1999/02/18～2002/02/18	Taishin Holdings
Shih Kong Life	1999/02/19～2002/02/19	Shin Kong Holdings
International Bills Financial Corporation	1999/03/26～2002/03/26	Waterland Holdings
Bank SinoPac	1999/05/09～2002/05/09	SinoPac Holdings
Chinatrust Bank	1999/05/07～2002/05/07	Chinatrust Holdings
First Bank	2000/01/02～2003/01/02	First Holdings
Jih Sun Bank	1999/02/05～2002/02/05	Jih Sun Holdings

Table 4 VaR values for financial holding companies

financial holding companies	Monte Carlo simulation method	Bootstrap method	Historical simulation method
Huanan Holdings	0.1087	0.0686	0.0704
Fubong Insurance	0.0482	0.0525	0.0547
Cathay Holdings	0.0760	0.0557	0.0488
China Development Holdings	0.1052	0.0637	0.0574
E. Sun Bank	0.0874	0.0636	0.0625
Fuhwa Holdings	0.0598	0.0691	0.0621
Mega Holdings	0.0645	0.0676	0.0666
Taishin Holdings	0.0841	0.0647	0.0648
Shin Kong Holdings	0.0902	0.0668	0.0711
WaterLand Holdings	0.0528	0.0639	0.0650
SinoPac Holdings	0.0500	0.0557	0.0458
Chinatrust Holdings	0.0536	0.0496	0.0458
First Holdings	0.0617	0.0668	0.0544
Jih Sun Holdings	0.0570	0.0677	0.0585

Table 5 VaR values for primary companies

primary company	Monte Carlo simulation method	Bootstrap method	Historical simulation method
Huanan Bank	0.0705	0.0668	0.0704
Fubon Insurance	0.0707	0.0671	0.0690
Cathay Life	0.0680	0.0659	0.0687
China Development Industrial Bank	0.0711	0.0662	0.0691
E. Sun Bank	0.0640	0.0665	0.0611
Fuhwa Securities	0.0699	0.0665	0.0647
Chiao Tung Bank	0.0697	0.0670	0.0717
Taishih Bank	0.0726	0.0666	0.0709
Shih Kong Life	0.0683	0.0664	0.0643
International Bills Financial Corporation	0.0719	0.0663	0.0705
Bank SinoPac	0.0662	0.0665	0.0687
Chinatrust Bank	0.1491	0.0665	0.0701
First Bank	0.1464	0.0663	0.0706
Jih Sun Bank	0.0637	0.0663	0.0603

Table 6 Kupiec Backtests for primary companies

primary company	Monte Carlo simulation method			Bootstrap method			Historical simulation method		
	# of failure	probability model is correct	failure ratio	# of failure	probability model is correct	failure ratio	# of failure	probability model is correct	failure ratio
Huanan Bank	13	0.0259	0.0168	16	0.0025	0.0207	8	0.3682	0.0104
Fubon Insurance	12	0.0360	0.0164	9	0.2036	0.0123	5	0.7408	0.0068
Cathay Life	9	0.2582	0.0115	11	0.097	0.0141	8	0.3794	0.0103
China Development Industrial Bank	4	0.8945	0.0051	11	0.1024	0.014	8	0.3906	0.0102
E. Sun Bank	2	0.9833	0.0026	6	0.6524	0.0078	7	0.5078	0.0091
Fuhwa Securities	6	0.6511	0.0078	7	0.5064	0.0091	8	0.3668	0.0104
Chiao Tung Bank	16	0.0024	0.0208	18	3.89E-04	0.0233	8	0.3688	0.0104
Taishih Bank	1	0.9962	0.0013	24	4.95E-07	0.0312	8	0.3654	0.0104
Shih Kong Life	3	0.9500	0.0039	5	0.7841	0.0065	8	0.3696	0.0103
International Bills Financial Corporation	3	0.9476	0.0039	16	0.0023	0.0209	8	0.3599	0.0104
Bank SinoPac	12	0.0471	0.0157	12	0.0471	0.0157	8	0.3571	0.0105
Chinatrust Bank	0	0.9996	0	16	0.0024	0.0208	8	0.3668	0.0104
First Bank	0	0.9995	0	24	3.38E-07	0.0318	9	0.2273	0.0119
Jih Sun Bank	6	0.6511	0.0078	7	0.5064	0.0091	7	0.5064	0.0091

Table 7 Kupiec Backtests for financial holding companies

financial holding company	Monte Carlo simulation method			Bootstrap method			Historical simulation method		
	# of failure	probability model is correct	failure ratio	# of failure	probability model is correct	failure ratio	# of failure	probability model is correct	failure ratio
Huanan Holdings	1	0.9949	0.0014	13	0.0184	0.0176	8	0.3198	0.0109
Fubong Insurance	11	0.0720	0.0149	9	0.2102	0.0122	8	0.3226	0.0108
Cathay Holdings	0	0.9994	0	4	0.8625	0.0054	8	0.3253	0.0108
China Development Holdings	1	0.9945	0.0014	6	0.5949	0.0082	8	0.3103	0.0110
E. Sun Bank	0	0.9994	0	6	0.6090	0.0081	8	0.3239	0.0108
Fuhwa Holdings	10	0.1274	0.0135	3	0.9373	0.0041	8	0.3226	0.0108
Mega Holdings	9	0.2102	0.0122	7	0.4595	0.0095	8	0.3226	0.0108
Taishin Holdings	1	0.9951	0.0013	8	0.3253	0.0108	8	0.3253	0.0108
Shin Kong Holdings	1	0.9950	0.0014	15	0.0039	0.0203	8	0.3239	0.0108
WaterLand Holdings	18	2.44e-004	0.0243	9	0.2136	0.0121	8	0.3267	0.0108
SinoPac Holdings	1	0.9950	0.0014	7	0.4595	0.0095	8	0.3226	0.0108
Chinatrust Holdings	5	0.7408	0.0068	7	0.4506	0.0095	8	0.3144	0.0109
First Holdings	7	0.4580	0.0095	3	0.9369	0.0041	8	0.3212	0.0108
Jih Sun Holdings	10	0.1249	0.0136	6	0.6034	0.0082	8	0.3185	0.0109

Table 8 Expected returns for primary companies

primary company	expected return
Bank SinoPac	-0.014670
Cathay Life	-0.069537
Chiao Tung Bank	0.022730
China Development Industrial Bank	-0.012673
Chinatrust Bank	-0.045411
E. Sun Bank	0.045981
First Bank	0.139102
Fubong Insurance	0.030168
Fuhwa Securities	-0.009742
Huanan Bank	-0.052128
International Bills Financial Corporation	-0.030499
Jih Sun Bank	-0.001818
Shih Kong Life	0.006241
Taishih Bank	0.115050

Table 9 Expected returns for financial holding companies

financial holding company	expected return
Cathay Holdings	0.066578
China Development Holdings	-0.131567
Chinatrust Holdings	0.038888
E. Sun Holdings	0.040109
First Holdings	0.035599
Fubong Holdings	-0.025283
Fuhwa Holdings	-0.023729
Huanan Holdings	0.082057
Jih Sun Holdings	-0.014619
Mega Holdings	0.091023
Shin Kong Holdings	-0.020262
SinoPac Holdings	0.008905
Taishih Holdings	0.011066
Waterland Holdings	-0.025866

Table 10 RAROC values for primary companies

primary company	expected return	VaR	# of failure	multiplier factor	RAROC
Bank SinoPac	-0.0147	0.0687	8	3	-0.07118
Cathay Life	-0.0695	0.0687	8	3	-0.33739
Chiao Tung Bank	0.0227	0.0717	8	3	0.105672
China Development Industrial Bank	-0.0127	0.0711	4	3	-0.05941
Chinatrust Bank	-0.0454	0.1491	0	3	-0.10152
E. Sun Bank	0.0460	0.0720	2	3	0.212875
First Bank	0.1391	0.1464	0	3	0.316717
Fubong Insurance	0.0302	0.0690	5	3	0.145739
Fuhwa Securities	-0.0097	0.0699	6	3	-0.04646
Huanan Bank	-0.0521	0.0704	8	3	-0.24682
International Bills Financial Corporation	-0.0305	0.0719	3	3	-0.1414
Jih Sun Bank	-0.0018	0.0675	6	3	-0.00898
Shih Kong Life	0.0062	0.0713	3	3	0.029177
Taishih Bank	0.1151	0.0726	1	3	0.528237

Table 11 RAROC values for financial holding companies

financial holding company	expected return	VaR	# of failure	multiplier factor	RAROC
Cathay Holdings	0.0666	0.0760	0	3	0.292009
China Development Holdings	-0.1316	0.1052	1	3	-0.41688
Chinatrust Holdings	0.0389	0.0536	5	3	0.241841
E. Sun Holdings	0.0401	0.0874	0	3	0.152971
First Holdings	0.0356	0.0668	3	3	0.17764
Fubong Holdings	-0.0253	0.0547	8	3	-0.15407
Fuhwa Holdings	-0.0237	0.0691	3	3	-0.11447
Huanan Holdings	0.0821	0.1087	1	3	0.251631
Jih Sun Holdings	-0.0146	0.0677	6	3	-0.07198
Mega Holdings	0.0910	0.0676	7	3	0.448831
Shih Kong Holdings	-0.0203	0.0902	1	3	-0.07488
SinoPac Holdings	0.0089	0.0750	1	3	0.039578
Taishih Holdings	0.0111	0.0841	1	3	0.04386
Waterland Holdings	-0.0259	0.0650	8	3	-0.13265

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